weight to height, good and bad blood pressure readings, and normal and abnormal electrocardiograms. These entities in turn depended on new instruments, such as sphygmomanometers and EKG machines. They required also the coming into being of new kinds of people: technicians to operate the instruments, specialists in computation to manipulate the numbers, and even a subtly redefined physician, who has learned to rely less on the feel of the pulse and the complaints of the patient and more on laboratory reports. New scientific objects come into being only in alliance with the right kinds of instruments and the right kinds of people. The linkage is not so tight as to exclude the detection of new objects by old researchers or of old objects by new instruments, but we can identify conditions that favor the multiplication of entities. Here, in insurance medicine, a leading role was played by large, resolutely impersonal institutions. Similar considerations apply, though often more subtly, to basic scientific research as well.

It would be about as helpful to argue that the blood had no pressure before insurance companies began pushing the use of sphygmomanometers as it would be to claim there was no mortality before there were actuaries. The "coming into being" of quantitative entities like these should rather be understood in terms of a selection among alternative ways of knowing. Often, as in the present case, that choice is shaped by a variety of interests and constraints. The shift toward standardization and objectivity in this story of insurance medicine cannot be regarded as the inevitable product of science or modernization or bureaucratic rationality. Rather, it was an adaptation to a very particular context of use, in which agents, physicians, business executives, government regulators, and even the unforthcoming applicants played as decisive a role as did medical directors and actuaries.

10 Bruno Latour

On the Partial Existence of Existing and *Nonexisting Objects*

PROLOGUE: DID RAMSES II DIE OF TUBERCULOSIS?

In 1976, the mummy of Ramses II was welcomed at a Paris air base with the honors due to a head of state, greeted by a minister, trumpets, and the Republican Guards in full attire. As hinted at in the fiery title of *Paris-Match*—"Nos savants au secours de Ramsès II tombé malade 3000 ans *après sa mort*" (Our scientists to the rescue of Ramses II, who fell ill three thousand years *after his death*)—something is at stake here that defies the normal flow of time.[1] Sickness erupts after death and the full benefit of modern technology arrives a tiny bit too late for the great king. In this stunning picture (figure 10.1), the mummy is being operated upon on the surgical table, violently lit by floodlights, surrounded by "our scientists" in white coats wearing masks against contagion (either to protect Ramses against their modern-made germs or to protect themselves from Pharaoh's curse). After careful examination, the verdict of the postmortem ("post" indeed!) is offered: Ramses II had very bad teeth, a terrible deformation of

This chapter remains close to the paper written for the conference that is at the origin of this book. A much modified version, more technical and more philosophical, has been published as chapter 5 of *Pandora's Hope: Essays in the Reality of Science Studies* (Cambridge: Harvard University Press, 1999).

1. In spite of the flippant titles usual for *Paris-Match*, a reading of the text shows that it is not actually the king who has become sick after his death, but rather the mummy, from an infection by a fungus. I nonetheless have kept the first interpretation, associated with the image, because of its ontological interest. All the details on the mummy transportation and cure can be found in Christiane Desroches-Noblecourt, *Ramsès II, la véritable histoire* (Paris: Pygmalion, 1996).

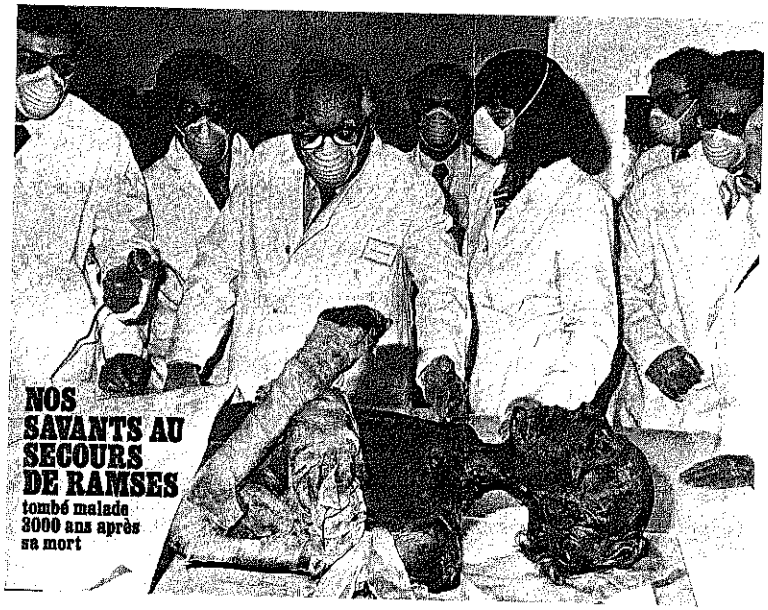

Figure 10.1. Our scientists to the rescue of Ramses II, who fell ill three thousand years *after his death*. (From *Paris Match*, September 1956)

the spinal cord that caused extreme pain. Too late for an intervention. But not too late to claim still another triumph for French physicians and surgeons, whose reach has now expanded in remote time as well as in remote space.

The great advantage of this picture is that it renders visible, tangible, and material the expense at which it is possible for us to think of the extension in space of Koch's bacillus, discovered (or invented, or made up, or socially constructed) in 1882. Let us accept the diagnosis of "our brave scientists" at face value and take it as a proved fact that Ramses died of tuberculosis. How could he have died of a bacillus discovered in 1882 and of a disease whose etiology, in its modern form, dates only from 1819 in Laënnec's ward? Is it not anachronistic? The attribution of tuberculosis and Koch's bacillus to Ramses II should strike us as an anachronism of the same caliber as if we had diagnosed his death as having been caused by a Marxist upheaval, or a machine gun, or a Wall Street crash. Is it not an extreme case of "whiggish" history, transplanting into the past the hidden or potential existence of the future? Surely, if we want to respect actors' categories, there must be in the Egyptian language a term and a set of hieroglyphs, for instance

"Saodowaoth," that define the cause of Ramses' death. But if it exists it is so incommensurable with our own interpretations that no translation could possibly replace it by "an infection of Koch's bacillus." Koch bacilli have a local history that limits them to Berlin at the turn of the century. They may be allowed to spread to all the years that come *after* 1882 provided Koch's claim is accepted as a fact and incorporated later into routine practices, but certainly they cannot jump back to the years *before*.

And yet, if we immediately detect the anachronism of bringing a machine gun, a Marxist guerilla movement, or a Wall Street capitalist back to the Egypt of 1000 B.C., we seem to swallow with not so much as a gulp the extension of tuberculosis to the past. More exactly, for *this* type of object at least, we seem to be torn between two opposite positions. The first one, which would be a radically anti-whiggish history, forbids us from ever using the expression "Ramses II died of tuberculosis" as a meaningful sentence. We are allowed only to say things like "our scientists have started in 1976 to interpret Ramses II's death as having been caused by tuberculosis but, at the time, it was interpreted as being caused by 'Saodowaoth' or some such word. Saodowaoth is not a translation of tuberculosis. There is no word to translate it. The cause of Ramses' death is thus unknown and should remain irretrievable in a past from which we are infinitely distant." The second solution is a sort of self-confident, laid-back whiggism that accepts tuberculosis and Koch's bacillus as the long-expected and provisionally final revelation of what has been at work all along in the course of history. Saodowaoth and all such gibberish disappear as so many mistakes; what really happened is eventually exposed by "our brave scientists."

Fortunately, there is another solution that is revealed by this picture and by the work that has been carried out, for a generation now, on the practice of science. Koch bacillus can be extended into the past to be sure—contrary to the radical anti-whiggish position—, but this cannot be done *at no cost*. To allow for such an extension, some work has to be done, especially some laboratory work. The mummy has to be *brought into contact* with a hospital, examined by white-coat specialists under floodlights, the lungs X-rayed, bones sterilized with cobalt 60, and so on. All this labor-intensive practice is quietly ignored by the whiggish position, which speaks of the extension in time as if it were a simple matter, requiring no laboratory, no instrument, no specially trained surgeon, no X rays. What is made clear by the *Paris-Match* picture is that Ramses II's body can be endowed with a new feature: tuberculosis. But none of the elements necessary to prove it can themselves be expanded or transported back to three thousand years ago. In other words, Koch's bacillus may travel in time, not the hospital surgeons,

not the X-ray machine, not the sterilization outfit. When we impute retroactively a modern shaped event to the past we have *to sort out* the fact—Koch bacillus's devastating effect on the lung—with that of the material and practical setup necessary to render the fact visible. It is only if we believe that facts *escape* their network of production that we are faced with the question whether or not Ramses II died of tuberculosis.

The problem appears difficult only for *some type* of objects and only for the *time* dimension. Obviously, no one could have the same worry for a machine gun, unless we invent a time capsule. It is impossible for us to imagine that a machine gun could be transported into the past. Thus, technological objects do not have the same popular ontology and cannot travel *back* into the past under any circumstances, which might be one way of saying that the philosophy of technology is a better guide for ontology than the philosophy of science. For technology, objects *never* escape the conditions of their productions. An isolated machine gun in the remote past is a pragmatic absurdity—and so, by the way, is an isolated machine gun in the present without the know-how, bullets, oil, repairmen, and logistics necessary to activate it. Another advantage of a technological artifact is that we have no difficulty in imagining that it rusts away and disappears. Thus it always remains tied to a circumscribed and well-defined spatiotemporal envelope.[2] An isolated Koch bacillus is also a pragmatic absurdity since those types of facts cannot escape their networks of production either. Yet we seem to believe they can, because for science, *and for science only,* we forget the local, material, and practical networks that accompany artifacts through the whole duration of their lives.

Of course, we have learned, after reading science studies of all sorts, that facts cannot, even by the wildest imagination, escape their local conditions of production. We now know that even to verify such a universal fact as gravitation we need somehow to connect the local scene with a laboratory through the crucial medium of metrology and standardization. And yet, we rarely believe this to be the case in the *remote future*—there seems to be a time when the Koch bacillus proliferates everywhere without bacteriological laboratories—and in the *remote past*—there seems to be no need for a network to attach Ramses II to a diagnosis. Unlike technological artifacts, scientific facts seem, once we wander away from the local conditions of production in the past as well as in the future, to free themselves from their spatiotemporal envelope. Inertia seems to take over at no cost. The great lesson

2. Except in the Frankensteinian nightmares. See my *Aramis or the Love of Technology,* trans. Catherine Porter (Cambridge: Harvard University Press, 1996). On the layering aspect of technologies see the marvelous novel by Richard Powers, *Galatea* 2.2 (New York: Farrar, Strauss and Giroux, 1995).

of the picture shown above is that extension in the past, extension in the future, and extension in space may require the *same* type of labor. In the three cases, the local scene should be hooked up to laboratory practice through some sort of extended or standardized or metrologized network. It is impossible to pronounce the sentence "Ramses II died of tuberculosis" without bringing back all the pragmatic conditions that give truth to this sentence.

In other words, provided that (1) we treat all scientific objects like technological projects, (2) we treat all expansion in time as being as difficult, costly, and fragile as extensions in space, and (3) we consider science studies to be the model that renders *impossible* the escape of a fact from its network of production, then we are faced with a new ontological puzzle: the thorough historicization not only of the *discovery* of objects, but of those objects *themselves*. By learning the lesson of this picture, we might provide a network account of reality that would escape both whiggish and radical anti-whiggish metaphysics.

PURGING OUR ACCOUNTS OF FOUR ADVERBS: NEVER, ALWAYS, NOWHERE, EVERYWHERE

To formulate the question of this essay, let me generalize the two questions of the prologue (What happened after 1976 to "Saodowaoth," the name wrongly given to the cause of Ramses' death? Where were the Koch bacilli *before* 1882 and 1976?):

- Where were the objects that no longer exist when they existed in their limited and historically crooked ways?
- Where were the objects that now exist before they acquired this decisive and no longer historical mode of existence?

I will not try to answer these questions at the philosophical and ontological level,[3] which I could call "historical realism"—*not* historical materialism!—in which the notions of events, relations, and propositions play the dominant role. My goal in this essay, although theoretical, is not philosophical. I simply want to dig out the theory of "relative existence" embedded in what could be called the "best practice" of historians of science and science studies. Not that I want to give them a lesson. I am simply interested in mapping a common ground, a common vocabulary, that would be *intermediary* between the practice of historical narrative in the social his-

3. For this see my *Pandora's Hope: Essays in the Reality of Science Studies* (Cambridge: Harvard University Press, 1999).

tory of science on the one hand and the ontological questions that are raised by this practice on the other. My idea is simply that in the last twenty years historians of science have raised enough problems, monsters, and puzzles, such as that of Ramses II's cause of death, to keep philosophers, metaphysicians, and social theorists busy for decades. The *middle ground* I want to explore here could at least prevent us from asking the wrong questions of the historical narratives at hand, and should help focus our attention on new questions hitherto hidden by the fierce debates between realism and relativism.

To give some flesh to the theoretical questions raised here, I will use, not the case of Ramses II (about which I do not know enough), but the debates between Pasteur and Pouchet over spontaneous generation. I do not wish here to add anything to its historiography, but to use it precisely because it is so well known that it can be used as a convenient topos for all readers.[4]

What is relative existence? It is an existence that is no longer framed by the choice between never and nowhere on the one hand, and always and everywhere on the other. If we start by having to choose between these positions imposed upon us by the traditional formulations of the philosophy of science, we cannot hope to fulfil the goals of this book. Pouchet's spontaneous generation will have *never* been there *anywhere* in the world; it was an illusion all along; it is not allowed to have been part of the population of entities making up space and time. Pasteur's ferments carried by the air, however, have *always* been there, all along, *everywhere*, and have been bona fide members of the population of entities making up space and time long before Pasteur. To be sure, historians can tell us a few amusing things on why Pouchet and his supporters wrongly believed in the existence of spontaneous generation, and why Pasteur fumbled a few years before finding the right answer, but the tracing of those zigzags gives us no new essential information on the entities in question. Although they provide information on the subjectivity and history of *human* agents, history of science, in such a rendering, does not provide any other information on what makes up *nonhuman* nature. By asking a nonhuman entity to exist—

4. John Farley, "The Spontaneous Generation Controversy—1700–1860: The Origin of Parasitic Worms," *Journal of the History of Biology* 5 (1972): 95–125; John Farley, *The Spontaneous Generation Controversy from Descartes to Oparin* (Baltimore: Johns Hopkins University Press, 1974); Gerald Geison, *The Private Science of Louis Pasteur* (Princeton: Princeton University Press, 1995); Richard Moreau, "Les expériences de Pasteur sur les générations spontanées: Le point de vue d'un microbiologiste," parts 1 ("La fin d'un mythe") and 2 ("Les conséquences"), *La vie des sciences* 9, no. 3 (1992): 231–60; no. 4 (1992): 287–321; Bruno Latour, "Pasteur and Pouchet: The Heterogenesis of the History of Science," in *History of Scientific Thought*, ed. Michel Serres (London: Blackwell, 1995), 526–55.

or more exactly to have existed—either never-nowhere or always-everywhere, the epistemological question limits historicity to humans and artifacts and bans it for nonhumans.

Contrary to this popular version of the role of history in science, it could be said that the new social or cultural history of science is defined by the *generalization of historicity*, usually granted only to social, technological, and psychological agency, to natural agencies. No one, even his French worshipers, will ask the question, "Where was Pasteur *before* 1822?" Or will require Pouchet to have been nonexistent in 1864—when he disputes Pasteur's findings—under the pretext that he was defeated by Pasteur. Relative existence is exactly what we are used to dealing with in human history; it is also what we take for granted for technological artifacts. None of the social and technical events making up a historical narrative have to be put into the Procrustean bed of never-nowhere or always-everywhere. Existing somewhat, having a little reality, occupying a definitive place and time, having predecessors and successors: those are the normal ways of delineating the spatiotemporal envelope of history. These are exactly the kind of terms and expressions that should be used, from now on, for spontaneous generation itself and for the germs carried by the air.

Let me try a very sketchy history, the narrative of which relies on this symmetrical historicization. Spontaneous generation was a very important phenomenon in a Europe devoid of refrigerators and preserves, a phenomenon everyone could easily reproduce in one's kitchen, an undisputed phenomenon made more credible through the dissemination of the microscope. Pasteur's denial of its existence, on the contrary, existed only in the narrow confines of the rue d'Ulm laboratory, and only insofar as he was able to prevent what he called "germs" carried by the air to enter the culture flasks. When reproduced in Rouen, by Pouchet, the new material culture and the new bodily skills were so fragile that they could not migrate from Paris to Normandy and spontaneous generation proliferated in the boiled flasks as readily as before. Pasteur's successes in *withdrawing* Pouchet's common phenomenon from space-time required a gradual and punctilious *extension* of laboratory practice to each site and each claim of his adversary. "Finally," the whole of emerging bacteriology, agribusiness, and medicine, by relying on this new set of practices, eradicated spontaneous generation, which, using the past perfect, they had transformed into something that, although it had been a common occurrence for centuries, was now a belief in a phenomenon that "had never" existed "anywhere" in the world. This expulsion and eradication, however, required the writing of textbooks, the making of historical narratives, the setup of many institutions from universities to the Pasteur Museum. Much work had to be

done—has still to be done, as we will see below—to maintain Pouchet's claim as a belief in a nonexistent phenomenon.

I put "finally" above in quotation marks, because if, to this day, you reproduce Pouchet's experiment in a defective manner, by being, for instance like me, a poor experimenter, not linking your bodily skills and material culture to the strict discipline of asepsis and germ culture learned in microbiology laboratories, the phenomena supporting Pouchet's claims will still appear.[5] Pasteurians of course will call it "contamination," and if I wanted to publish a paper vindicating Pouchet's claims and reviving his tradition based on my observations no one would publish it. But if the collective body of precautions, the standardization, the disciplining learned in Pasteurian laboratories were to be interrupted, not only by me, the bad experimenter, but by a whole generation of skilled technicians, then the decision about who won and who lost would be made uncertain again. A society that would no longer know how to cultivate microbes and control contamination would have difficulty in judging the claims of the two adversaries of 1864. There is no point in history where a sort of inertial force can be counted on to take over the hard work of scientists and relay it for eternity.[6] For scientists there is no Seventh Day!

What interests me here is not the accuracy of this account, but rather the *homogeneity* of the narrative with one that would have described, for instance, the rise of the radical party, from obscurity under Napoleon III to prominence in the Third Republic, or the expansion of Diesel engines into submarines. The demise of Napoleon III does not mean that the Second Empire never existed; nor does the slow expulsion of Pouchet's spontaneous generation by Pasteur mean that it was *never* part of nature. In the same way that we could still, to this day, meet Bonapartists, although their chance of becoming president is nil, I sometimes meet spontaneous generation buffs who defend Pouchet's claim by linking it, for instance, to prebiotics and who want to rewrite history again, although they never manage to get their "revisionist" papers published. Both groups have now been pushed to the fringe, but their mere presence is an interesting indication that the "finally" that allowed philosophers of science, in the first model, definitively to clean the world of entities that have been proved wrong was too brutal. Not only is it brutal; it also ignores the mass of work that still

5. I had the chance in 1992 for the twenty-fifth anniversary of my center to redo those experiments in the company of Simon Schaffer. See the essay in this volume by Hans-Jörg Rheinberger.

6. See the interesting notion of "grey boxes" in Kathleen Jordan and Michael Lynch, "The Mainstreaming of a Molecular Biological Tool," *Technology in Working Order: Studies of Work, Interaction, and Technology*, ed. G. Button (London: Routledge, 1993).

has to be done, daily, to activate the "definitive" version of history. After all, the Radical party disappeared, as did the Third Republic, for lack of massive investments in democratic culture, which, like microbiology, has to be taught, practiced, kept up, sunk in. It is always dangerous to imagine that, at some point in history, *inertia* is enough to keep up the reality of phenomena that have been so difficult to produce. When a phenomenon "definitely" exists this does not mean that it exists forever, or independently of all practice and discipline, but that it has been entrenched in a costly and massive *institution* that has to be monitored and protected with great care (see below). This is a lesson that was learned the hard way both by democrats who saw the Third Republic flounder in the hands of Vichy, and by the historians who saw, to their dismay, the negationists gain credit in France. "Inertia," obviously, was no protection against reopening of controversies.

DEMARCATION IS THE ENEMY OF DIFFERENTIATION

How can we now map the two destinies of Pasteur's and Pouchet's claims without appealing to the two dragons, the Faffner of never-nowhere and the Fasolt of always-everywhere? Do we have to embrace a simpleminded relativism and claim that both arguments are historical, contingent, localized, and temporal, and thus cannot be differentiated, each of them being able, given enough time, to revise the other into nonexistence? This is what the two dragons claim, or more exactly roar threateningly. Without them, they boast, only an undifferentiated sea of equal claims will appear, engulfing at once democracy, common sense, decency, morality, and nature . . . The only way, according to them, to escape relativism is to withdraw from history and locality every fact that has been proven right, and to stock it safely in a nonhistorical nature where it has always been and can no longer be reached by any sort of revision. *Demarcation*, for them, is the key to virtue and, for this reason, historicity is then maintained only for humans, radical parties, and emperors, while nature is periodically purged of all the nonexistent phenomena that clutter Her. In this demarcationist view, history is simply a way for humans to access nonhistorical nature, a convenient intermediary, a necessary evil, but it should not be, according to the two dragon keepers, a durable mode of existence for facts.

These claims, although they are often made, are both inaccurate and dangerous. Dangerous, because, as I have said, they forget to *pay the price* of keeping up the institutions that are necessary for maintaining facts in durable existence, relying instead on the free inertia of ahistoricity. But, more importantly for this book, they are *inaccurate*. Nothing is easier than

to differentiate in great detail the claims of Pasteur and Pouchet. This differentiation, contrary to the claims of our fiery keepers, is made even more telling once we abandon the boasting and empty privilege they want for nonhumans over human events. Demarcation is here the enemy of differentiation. The two dragons behave like eighteenth-century aristocrats who claimed that civil society would crash if it was not solidly held up by their noble spines and was delegated instead to the humble shoulders of many commoners. It happens that civil society is actually rather better maintained by the many shoulders of citizens than by the Atlas-like contortions of those pillars of cosmological and social order. It seems that the same demonstration is to be made for differentiating the spatiotemporal envelopes deployed by historians of science. The common historians seem to do a much better job at maintaining differences than the towering epistemologists.

Let us compare the two accounts by looking at figure 10.2. In those diagrams existence is not an all-or-nothing property but a relative property

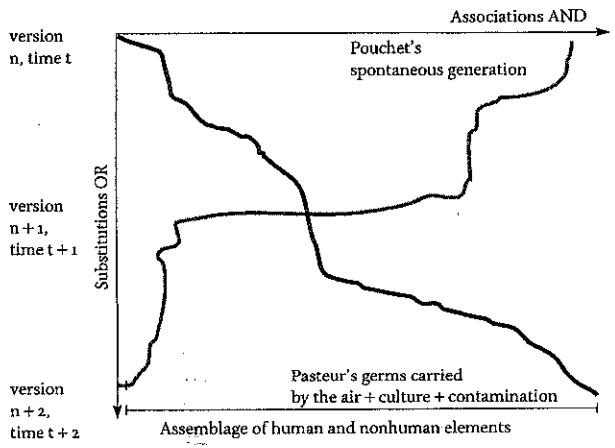

Figure 10.2. Relative existence may be mapped according to two dimensions: association (AND), that is, how many elements cohere at a given time, and substitution (OR), that is, how many elements in a given association have to be modified to allow other new elements to cohere with the project. The result is a curve in which every modification in the associations is "paid for" by a move in the other dimension. Pouchet's spontaneous generation becomes less and less real, and Pasteur's culture method becomes more and more real after undergoing many transformations. (From Bruno Latour, *Pandora's Hope* [Cambridge: Harvard University Press, 1999], 159; copyright © 1999 by the President and Fellows of Harvard College. Reprinted by permission of Harvard University Press)

that is conceived of as the *exploration* of a two-dimensional space made by association and substitution, AND and OR. An entity gains in reality if it is associated with many others that are viewed as collaborating with it. It loses in reality if, on the contrary, it has to shed associates or collaborators (humans and nonhumans). Thus, these diagrams do not consider any final stage in which historicity will be abandoned to be relayed by inertia, ahistoricity, and naturalness—although very well known phenomena like black-boxing, socialization, institutionalization, standardization, and training will be able to account for the smooth and ordinary ways in which they would be treated. Matters of fact become matters of course. At the bottom of the diagram, the reality of Pasteur's germ carried by the air is obtained through an ever greater number of elements with which it is associated—machines, gestures, textbooks, institutions, taxonomies, theories, and so on. The same definition can be applied to Pouchet's claims, which at version *n*, time *t*, are weak because they have lost almost all of their reality. The difference, so important to our dragon keepers, between Pasteur's expanding reality and Pouchet's shrinking reality is then pictured adequately. But this difference is only *as big as* the relation between the tiny segment on the left and the long segment at the right. It is *not* an *absolute* demarcation between what has never been there and what was always there. Both are relatively real and relatively existent, that is extant. We never say "it exists" or "it does not exist," but "this is the collective history that is enveloped by the expression 'spontaneous generation' or 'germs carried by the air.'"

The second dimension is the one that captures historicity. History of science does not document travel *through* time of an already existing *substance*. Such a move would accept too much from the dragons' requirements. History of science documents the modifications of the ingredients composing an association of entities. Pouchet's spontaneous generation, for instance, is made, at the beginning, of many elements: commonsense experience, anti-Darwinism, republicanism, Protestant theology, natural history skills in observing egg development, geological theory of multiple creations, Rouen natural museum equipment, etc.[7] In encountering Pasteur's opposition, Pouchet alters many of those elements. Each alteration, substitution, or translation means a move onto the vertical dimension of the diagram. To associate elements in a durable whole, and thus gain existence, he has to modify the list that makes up his phenomenon. But the new elements will not necessarily hold with the former ones, hence a move through the diagram space that dips—because of the substitution—and

7. Maryline Cantor, *Pouchet, savant et vulgarisateur: Musée et fécondité* (Nice: Z'éditions, 1994).

may move toward the left because of lack of associations between the newly "recruited" elements.

For instance, Pouchet has to learn a great deal of the laboratory practice of his adversary in order to answer the Academy of Sciences commissions, but, by doing this, he loses the support of the academy in Paris and has to rely more and more on republican scientists in the provinces. His associations might extend—for instance he gains large support in the anti-Bonapartist popular press—but the support he expected from the academy vanishes. The compromise between associations and substitutions is what I call exploring the socionatural phase space. Any entity is such an exploration, such an experience in what holds with whom, in who holds with whom, in what holds with what, in who holds with what. If Pouchet accepts the experiments of his adversary but loses the academy and gains the popular antiestablishment press, his entity, spontaneous generation, will be a *different* entity. It is not a substance crossing the nineteenth century. It is a set of associations, a syntagm, made of shifting compromise, a paradigm,[8] exploring what the nineteenth-century socionature may withhold. To Pouchet's dismay, there seems to be no way from Rouen to keep the following united in one single coherent network: Protestantism, republicanism, the academy, boiling flasks, eggs emerging de novo, his ability as natural historian, his theory of catastrophic creation. More precisely, if he wants to maintain this assemblage, he has to shift audiences and give his network a completely different space and time. It is now a fiery battle against official science, Catholicism, bigotry, and the hegemony of chemistry over sound natural history.[9]

Pasteur also explores the socionature of the nineteenth century, but his association is made of elements that, at the beginning, are largely distinct from those of Pouchet. He has just started to fight Liebig's chemical theory of fermentation and replaced it by a living entity, the ferment, the organic matter of the medium being there not to cause fermentation, as for Liebig, but to feed the little bug that no longer appears as a useless by-product of fermentation but as its sole cause.[10] This new emerging syntagm includes many elements: a modification of vitalism made acceptable against chemistry, a reemployment of crystallographic skills at sowing and cultivating entities, a position in Lille with many connections to agribusiness relying

8. In the linguist's usage of the word, not the Kuhnian one.

9. We should not forget here that Pouchet is not doing fringe science, but is being pushed to the fringe. At the time, it is Pouchet who seems to be able to control what is scientific by insisting that the "great problems" of spontaneous generation should be tackled only by geology and world history, not by going through Pasteur's flasks and narrow concerns.

10. See Latour, *Pandora's Hope*, chap. 4.

on fermentation, a brand-new laboratory, experiments in making life out of inert material, a circuitous move to reach Paris and the academy, etc. If the ferments that Pasteur is learning to cultivate, each having its own specific product—one for alcoholic fermentation, the other for lactic fermentation, a third for butyric fermentation—are also allowed to appear spontaneously, as Pouchet claims, then this is the end of the association of the entities already assembled by Pasteur. Liebig would be right in saying that vitalism is back; cultures in pure medium will become impossible because of uncontrollable contamination; contamination itself will have to be reformatted in order to become the genesis of new life forms observable under the microscope; agribusiness fermentation would no longer be interested in a laboratory practice as haphazard as its own century-old practice; etc.

In this very sketchy description, I am not treating Pasteur differently from Pouchet, as if the former were struggling with real uncontaminated phenomena and the second with myths and fancies. Both try their best to hold together as many elements as they can in order to gain reality. But those are not the *same* elements. An anti-Liebig, anti-Pouchet microorganism will authorize Pasteur to maintain the living cause of fermentation and the specificity of ferments, allowing him to control and to cultivate them inside the highly disciplined and artificial limits of the laboratory, thus connecting at once with the Academy of Science and agribusiness. Pasteur too is exploring, negotiating, trying out what holds with whom, who holds with whom, what holds with what, who holds with what. There is no other way to gain reality. But the associations he chooses and the substitutions he explores make a different socionatural assemblage, and each of his moves modifies the definition of the associated entities: the air, as well as the emperor, the laboratory equipment as well as the interpretation of Appert's preserves, the taxonomy of microbes as well as the projects of agribusiness.

SPATIOTEMPORAL ENVELOPES, NOT SUBSTANCES

I showed that we can sketch Pasteur's and Pouchet's moves in a symmetrical fashion, recovering as many differences as we wish between them without using the demarcation between fact and fiction. I also offered a very rudimentary map to replace judgments about existence or nonexistence by the spatiotemporal envelopes drawn when registering associations and substitutions, syntagms, and paradigms. What is being gained by this move? Why would science studies and history of science offer a better narrative to account for the relative existence of all entities than the one offered

by the notion of a substance remaining there forever? Why should adding the strange assumption of historicity of things to the historicity of humans simplify the narratives of both?

The first advantage is that we do not have to consider physical entities such as ferments, germs, or eggs sprouting into existence as being radically different from a *context* made of colleagues, emperors, money, instruments, body practices, etc. Each of the networks that makes up a version in the diagram above is a list of heterogeneous associations that includes humans and nonhuman elements. There are many philosophical difficulties with this way of arguing, but it has the great advantage of requiring us to stabilize neither the list of what makes up nature nor the list of what makes up context. Pouchet and Pasteur do not define the same physical elements—the first one seeing generation where the other sees contamination of cultures—nor do they live in the *same* social and historical context. Each chain of associations defines not only different links with the same elements, but different elements as well.

So, historians are no more forced to imagine one single nature of which Pasteur and Pouchet would provide different "interpretations" than they are to imagine one single nineteenth century imposing its imprint on historical actors. What is at stake in each of the two constructions is what God, the emperor, matter, eggs, vats, colleagues, etc. are able to do. To use a semiotic vocabulary, *performances* are what is needed in those heterogeneous associations, and not *competences* implying an hidden substrate or substance. Each element is to be defined by its associations and is an event created at the occasion of each of those associations. This will work for lactic fermentation, as well as for the city of Rouen, the emperor, the rue d'Ulm laboratory, God, or Pasteur's and Pouchet's own standing, psychology, and presuppositions. The ferments of the air are deeply modified by the laboratory at rue d'Ulm, but so is Pasteur, who becomes Pouchet's victor, and *so is the air* that is now separated, thanks to the swan neck experiment, into what transports oxygen on the one hand and what carries dust and germs on the other. In the narratives of historians of science, historicity is allocated to *all* the entities.

Second, as I said above, we do not have to treat the two envelopes asymmetrically by considering that Pouchet is fumbling in the dark with nonexisting entities while Pasteur is slowly targeting an entity playing hide-and-seek, while the historians punctuate the search by warnings like "cold!," "you are hot!," "you are warm!" Both Pasteur and Pouchet are associating and substituting elements, very few of which are similar, and experimenting with the contradictory requirements of each entity. The envelopes drawn by both protagonists are similar in that they are a spatiotemporal envelope that remains locally and temporally situated and empirically observable.

Third, this similarity does not mean that Pasteur and Pouchet are building the *same* networks and share the *same* history. The elements in the two associations have almost no intersection—apart from the experimental setting designed by Pasteur and taken over by Pouchet (none of the experimental designs of Pouchet was replicated by Pasteur, revealing a clear asymmetry here). Following the two networks in detail will lead us to visit completely different definitions of nineteenth-century socionature (as I have shown elsewhere, even the definition of Napoleon III is different).[11] This means that the incommensurability itself between the two positions—an incommensurability that seems so important for moral judgment—is itself the product of the slow differentiation of the two networks. In the end—a local and provisional end—Pasteur's and Pouchet's positions are incommensurable.

Thus, there is no difficulty in recognizing the differences in two networks once their basic similarity has been accepted. The spatiotemporal envelope of spontaneous generation has limits as sharp and as precise as those of germs carried by the air and contaminating microbe cultures in medium. The abyss between the claims that our two dragons challenged us to admit under threat of punishment is indeed there, but with an added bonus: the definitive demarcation where history stopped and naturalized ontology took over has disappeared. The advantage is important in rendering networks comparable at last because it allows us to go on qualifying, situating, and historicizing even the *extension* of "final" reality. When we say that Pasteur has won over Pouchet, and that now germs carried in the air are "everywhere," this everywhere can be documented empirically. Viewed from the Academy of Sciences, spontaneous generation disappeared in 1864 through Pasteur's work. But partisans of spontaneous generation lasted a long time and had the sentiment that they had conquered, Pasteur's chemical dictatorship receding into the fragile fortress of "official science." So they had the field to themselves, even though Pasteur and his colleagues felt the same way. Well, the comparison of the two "extended fields" is fea-

11. Bruno Latour, *Pasteur: une science, un style, un siècle* (Paris: Librairie académique Perrin, 1994). Pouchet, for instance, writes a letter to the emperor asking him for support in favor of spontaneous generation. Pasteur, the same year, also writes to ask for the emperor's support but this time to ask for his money, not for his opinion about the controversy. Do they write to the same emperor? No, since one is supposed to have an opinion and the other one money, one—Pouchet's emperor—is supposed to invade science and rectify the bad judgments of scientists, while the other is supposed to strictly respect the demarcation between science and politics but fully to support the former, keeping his opinions to himself.

sible without recurring to some incompatible and untranslatable "paradigms" that would forever estrange Pasteur from Pouchet. Republican, provincial natural historians, having access to the popular anti-Bonapartist press, maintain the extension of spontaneous generation. A dozen microbiology laboratories withdraw the existence of this phenomenon of spontaneous generation from nature and reformat the phenomena it was made of by the twin practices of pure medium culture and protection against contamination. The two are not incompatible paradigms (in the Kuhnian sense this time) by nature. They have been *made* incompatible by the series of associations and substitutions constructed by each of the two protagonists. They simply had fewer and fewer elements in common.

The reason why we find this reasoning difficult is that we imagine for microbes a substance that would be a little bit *more* than the series of its historical manifestations. We might be ready to grant that the set of performances remains always inside of the networks and that they are delineated by a precise spatiotemporal envelope, but we cannot suppress the feeling that the substance travels with fewer constraints than the performances. It seems to live a life of its own, having been, like the Virgin Mary in the dogma of Immaculate Conception, always already there, even before Eve's fall, waiting in Heaven to be translocated into Anna's womb at the right time. There is indeed a *supplement* in the notion of substance, but we should not, following the etymology of the word, "what lies underneath," imagine that this supplement resides "beneath" the series of its manifestations. Sociology offers a much better definition of substance with its notion of *institution*, that which is above a series of entities and makes them act as a whole. Yes, at the end of the nineteenth century, "the airborne germs" has become a whole, an organized and systematic body of practice that cannot be shattered. But this solidity, this wholeness, is to be accounted for by the fact that it is now institutionalized. "Substance" can now be redefined as the supplement of solidity and unity given to a series of phenomena by their routinization and black-boxing, and wrongly attributed to something lying below everything and possessing another life. The advantage of the notion of institution is that it is not difficult to entertain the idea that it has a history, a beginning and an end. With the notion of institution to account for their solidity and the notion of technical project[12] to account for their local deployment, natural facts become firmly attached to their spatiotemporal envelopes and stop hovering over their own bodies like ghosts.

12. Project, by opposition to object, is an original ontological state that has been well documented by recent history and sociology of technology. See above and, for instance, Wiebe Bijker, *Of Bicycles, Bakelites, and Bulbs: Toward a Theory of Sociotechnical Change* (Cambridge: MIT Press, 1995).

This reworking of the notion of substance is crucial because it points to a phenomenon that is badly accounted for by history of science: how do phenomena *remain in existence* without a law of inertia? Why can't we say that Pasteur is right and Pouchet wrong? Well, we can say it, but on the condition of making very precise the institutional mechanisms that are still at work to maintain the asymmetry between the two positions. In whose world are we now living? That of Pasteur or that of Pouchet? I don't know about you, but for my part, I live inside the Pasteurian network, every time I eat pasteurized yogurt, drink pasteurized milk, or swallow antibiotics. In other words, even to account for a lasting victory, one does not have to grant extrahistoricity to a research program that would suddenly, at some breaking or turning point, need *no* further upkeep. One simply has to go on historicizing and localizing the network and finding who and what make up its descendants. In this sense I partake in the "final" victory of Pasteur over Pouchet, in the same way that I partake in the "final" victory of republican over autocratic modes of governments by voting in the last presidential election instead of abstaining or refusing to be registered. To claim that such a victory requires no more work, no more action, no more institution, would be foolish. I can simply say that I live in this continued history.[13] To claim that the everywhere and always of such events cover the whole spatiotemporal manifold would be at best an exaggeration. Step away from the networks, and completely different definitions of yogurt, milk, and forms of government will appear and this time, not spontaneously . . .

GRANTING HISTORICITY TO OBJECTS

This solution, which is obvious for human-made historical events such as republics and for technological artifacts, seems awkward at first when applied to natural events because we do not want to share historicity with the nonhumans mobilized by the natural sciences. Under the influence of their antiempiricist fights, social historians of science understand by the expression "plasticity of natural facts" only the debates that humans agents have *about* them. Pasteur and Pouchet disagree about the interpretation of facts because, so the historians say, those facts are *underdetermined* and cannot, contrary to the claims of empiricists, force rational minds into assent. So the first task of social historians and social constructivists, following Hume's

13. See Isabelle Stengers, *L'invention des sciences modernes* (Paris: La Découverte, 1993), for this Whiteheadian argument on descendance and heritage. This is a pragmatist argument except that pragmatism is extended to things, and no longer limited to human relations with things.

line of attack, was to show that we, the humans, faced with dramatically underdetermined matters of fact, have to enroll other resources to reach consensus—our theories, our prejudices, our professional or political loyalties, our bodily skills, our standardizing conventions, etc. In their view, matters of fact had to be banned forever from narrative about scientific success, because either they were too underdetermined to shut down a controversy, or, worse, they could appear as the now bygone dispute closers of the realist tradition.

This tack, which looked reasonable at first, turned out to be at best a gross exaggeration of the abilities of social scientists to account for the closure of disputes, and at worst a devastating move delivering the new field of social historians straight into the teeth of Faffner and Fasolt. Why? Because social historians had to accept that historicity, like the now-dismantled apartheid in South African buses, was "for humans only," matters of fact playing no role at all in the controversy human agents have about them. Just what the dragons had roared all along . . . The acquiescence of the two archenemies, social constructivists and realists, to the very same metaphysics for opposed reasons has always been for me a source of some merriment.

A completely different source of plasticity and agitation can however be easily discovered; it is the one that resides in the matters of fact themselves. There is nothing in nature, in the series of causes and consequences, that dictates forever what ferments are supposed to do, to be, and how they have to behave once existence is defined as an event and that substances are redistributed into associations and relations. The germs carried by the air in Pasteur's rue d'Ulm air pump experiment are certainly not *the same* as those eggs that spontaneously appear at Rouen in Pouchet's flasks. They have to be the same only if a *sub*stance having no time and space is supposed to endure *under* the passing attributes that humans detect through their passing interpretations. But this is precisely the philosophy of existence that historians of science do not like to apply when offering their narratives of human, technological, and social-historical events. Applied to things, such a reluctance makes as much sense. Asking where the germs of the air of Paris were in 1864 at the rue d'Ulm, *before* 1864 and *away* from the rue d'Ulm, for instance in Rouen, has about as much meaning as asking where Pasteur was before he was born, and where the Second Empire was under Louis Philippe's reign. Answer: they were *not* there. To be sure, they had ascendants and predecessors, but those bear only family resemblances to them and relied on different associations.

It is only the threat of relativism, in the version advocated by the two dragons, and the threat of realism, in the version social constructivists have fought for twenty years, that forced us to expect a *better* answer, an answer

that would either *not* use the humans—nature being made of ahistorical objects—*nor* use the nonhumans—consensus being reached by human and social factors only. The joint historicity of humans and nonhumans appears to be, to my eyes at least, the totally unexpected discovery collectively made over two decades by historians and sociologists of science. It forces philosophy, which had so heavily relied on a definition of truth-value *superior* to the collective production of history—either by defending it or by dismantling it—to become *realist again*, but through a completely different route, that is, by extending historicity and sociability to nonhumans.

That this discovery could not be made by "straight" historians is obvious, since "that Noble Dream of Objectivity" forced them to deal with a human history full of noise and furors, which took place *inside a natural background* of naturalized entities that they took for granted. Only our tiny subprofession, dealing at once with the "human element" and the former "natural context," had to push the philosophy of history a little bit further, until it reached the point where the very distribution of roles into what does and what does not have history was performed. This point, to be made philosophically consistent, requires, to be sure, an enormous effort in collaboration with ontology, metaphysics, and the cognitive sciences. But to ignore or deny its existence would seem a pity now that so much has been achieved. Constructivism and realism are two *synonyms*, every builder knows that, but the differences between what does and what does not have a history has managed to transform, through the years, a constructivist position about natural entities into a critical, skeptical, and even deconstructionist position. Strange paradox of our intellectual history.

CONCLUSION: FREEING SCIENCE FROM POLITICS

I do not claim, in this chapter, to have presented philosophical arguments but simply to have cleared the intermediary zone between the narratives of the best practice of historians of science and science studies, on the one hand, and the ontological problems that should now be tackled to make sense of the historicity of things, on the other. What has, I hope, been made clearer is the question of the spatiotemporal envelope of phenomena.

If the enormous work of retrofitting that requires history telling, textbook writing, instrument making, body training, creation of professional loyalties and genealogies, is ignored, then the question "Where were the microbes before Pasteur?" takes on a paralyzing aspect that stupefies the mind for a minute or two. After a few minutes, however, the question becomes empirically answerable: Pasteur also took care to *extend* his local

production into other times and spaces and to make the microbes the substrate of others' unwitting action; the French surgeons take great pains to bring the mummy into direct contact with the hospital network so as to expand the existence of the Koch bacillus to span the three-thousand-year stretch and to be made visible inside the brittle bones. Yes, there are *substances* that have been there all along, but on the condition that they are made the substrate of activities, in the past as well as in space.[14] The always-everywhere might be reached, but it is costly, and its localized and temporal extension remains visible all the way. This can be made clearer through a look at figure 10.3.

When we say that Ramses II died of tuberculosis, we now know, almost automatically, that we should account for this extension of 1892 Koch bacillus onto the corpse of someone who has been dead for more than three millennia by taking into account the bringing of the mummy in 1976 to the surgical table of a high-tech bacteriologist. Yes, the bacillus has been there *all along*, but only *after* the sanitary flight to Paris that allowed "our scientists" to retrofit all of Egyptian history with a Pharaoh that, *from now on*, coughs and spits Koch's bacilli, even when disputing with Moses about how long the Ten Plagues will last . . . It might take a while before juggling effortlessly with those timings, but there is no logical inconsistency in talking about the extension in time of scientific networks, no more than there are discrepancies in following their extension in space. It can even be said that the difficulties in handling those apparent paradoxes are small compared to the smallest of those offered by quantum mechanics or cosmology.

A few elements should now be clear in this dialogue between history and philosophy.

- If the historicity of humans is treated separately from the ahistoricity of nonhumans, then the principle of symmetry (Bloor's one, which fights whiggism) cannot be fully enforced.
- If a substance is added that would lie under the relations of any entity—human or nonhuman, individual or collective—then distortions will appear immediately in the rendering of their history, the substance being unable to have the same timing and the same spread as its properties, one floating at no cost in time while the others are stuck inside the precise envelope of their flesh-and-blood networks; this distortion will produce artifactual differences among "making

14. So there are two practical meanings now given to the word "substance"; one is the institution that holds together a vast array of practical setups, as we saw above, and the other one is the retrofitting work that situates a more recent event as that which "lies beneath" an older one.

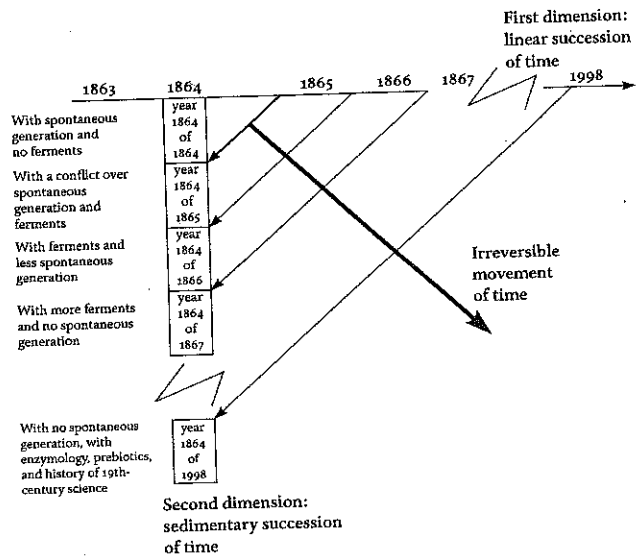

Figure 10.3. Time's arrow is the result of two dimensions, not one: the first dimension, the linear succession of time, always moves forward (1865 is *after* 1864); the second one, sedimentary succession, moves backward (1865 occurs *before* 1864). When we ask the question "Where was the ferment before 1865?" we do not reach the top segment of the column that makes up the year 1864, but only the transverse line that marks the contribution of the year 1865 to the elaboration of the year 1864. This, however, implies no idealism or backward causation, since time's arrow always moves irreversibly forward. (From Bruno Latour, *Pandora's Hope* [Cambridge: Harvard University Press, 1999], 171; copyright © 1999 by the President and Fellows of Harvard College. Reprinted by permission of Harvard University Press)

up," "inventing," "discovering," "constructing," "socially constructing," "deconstructing," etc.

- If existence and reality are detached at some turning point from the institutional practice that enforces them, and relayed from there on by a mysterious law of inertia, then it becomes impossible to extend the empirical research of historians to the stabilization, routinization, and standardization of "definitively" existing entities, in space *as well as* in time. For any entity to gain definitive access to existence, a deep rearrangement in space and time has to be worked out practically.
- If a sharp demarcation between existing and nonexisting objects is requested, in the manner made popular by the philosophy of lan-

guage, then the differentiation of the envelopes of various networks can no longer be made empirically clear, the battle for existence and nonexistence obfuscating the subtle explorations of *partial existences*. Demarcation, it should be underlined, is the moral, philosophical, and historical enemy of differentiation. The claim to morality made by demarcationists is entirely unwarranted since, on the contrary, relativism is the only way to pay the full cost of the extension in space and time of truth-values *and the maintenance* thereof.

• To avoid the dangers of relativism, especially those of having majority rule imposed in matters of knowledge, realists had to push matters of fact into nonhistorical nature *limiting* history to society and human passions; to avoid the dangers of realism, especially those of creating a suprasocial and suprahistorical scientific authority, social constructivists had to *abstain* from using matters of fact to account for the closure of historical controversies in science; the result was to imagine either that a nonhistorical and noncollective judge was necessary for differentiating knowledge claims, or that social history should never use things-in-themselves, except to debunk their claims to closure and expose their plasticity. However, as soon as historicity and socialization are extended to *all* members of collectives, the twin limits of relativism and realism are alleviated, as well as the strange metaphysics or political philosophy they thought necessary to endorse. As Whitehead shows in his cosmology, realism and relativism are synonymous expressions.

By this contribution, intermediary between philosophy and history of science—or better, ontology and the theory of history of science—I hope to have followed the intent of this volume and opened at least some conversations about the philosophy of history that would do justice to the more scholarly work presented in the other essays. A fascinating question to tackle now would be to understand why, if I am right in thinking that the thoroughgoing historicization here offered is neither inconsistent nor in danger of being morally bankrupt, it is nonetheless so difficult to entertain and so perilous to defend. What is especially puzzling to me is that many natural scientists have already rendered the world itself part of history, not only the living organisms of Darwinian theory but also cosmology.[15] Why

15. See the classic books of Stephen Jay Gould, esp. *Wonderful Life: The Burgess Shale and the Nature of History* (New York: W. W. Norton, 1989). It would probably be interesting to enter into a conversation with "evolutionary epistemology" at this point, for instance David L. Hull, *Science as a Process: An Evolutionary Account of the Social and Conceptual Development of Science* (Chicago: University of Chicago Press, 1988).

is time, if it is a good enough repository for animal bodies, for particles, for Big Bangs, not deemed stable enough for the knowledge claims made about those entities themselves? As if something else were needed, an Above and Beyond that could hold society and morality together? Something that, for purely contingent reasons, happens to be mixed up with the history of science, but is in no way related to the question of describing the sciences and accounting for their progress and demise. What progress could we make if we could disentangle the political question of maintaining social order from that of describing the history of the sciences? What step forward could be taken if we could depoliticize the sciences from the heavy burden that epistemology and Higher Superstitions have imposed on them for purely political reasons . . . ?